MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022/2023 (TERM ID 2210)

EET2066 – POWER TECHNOLOGY

(RE)

8 FEBRUARY 2023
2.30 p.m - 4.30 p.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question Paper consists of 6 pages excluding the cover page with 4 Questions only.

2. Attempt ALL questions. The distribution of the marks is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a)(i) Compare the switching speed and power loss in BJT and MOSFET. Assume the devices have similar size and rating. [2 marks]

(ii) List three advantages of a power MOSFET. [3 marks]

(b)

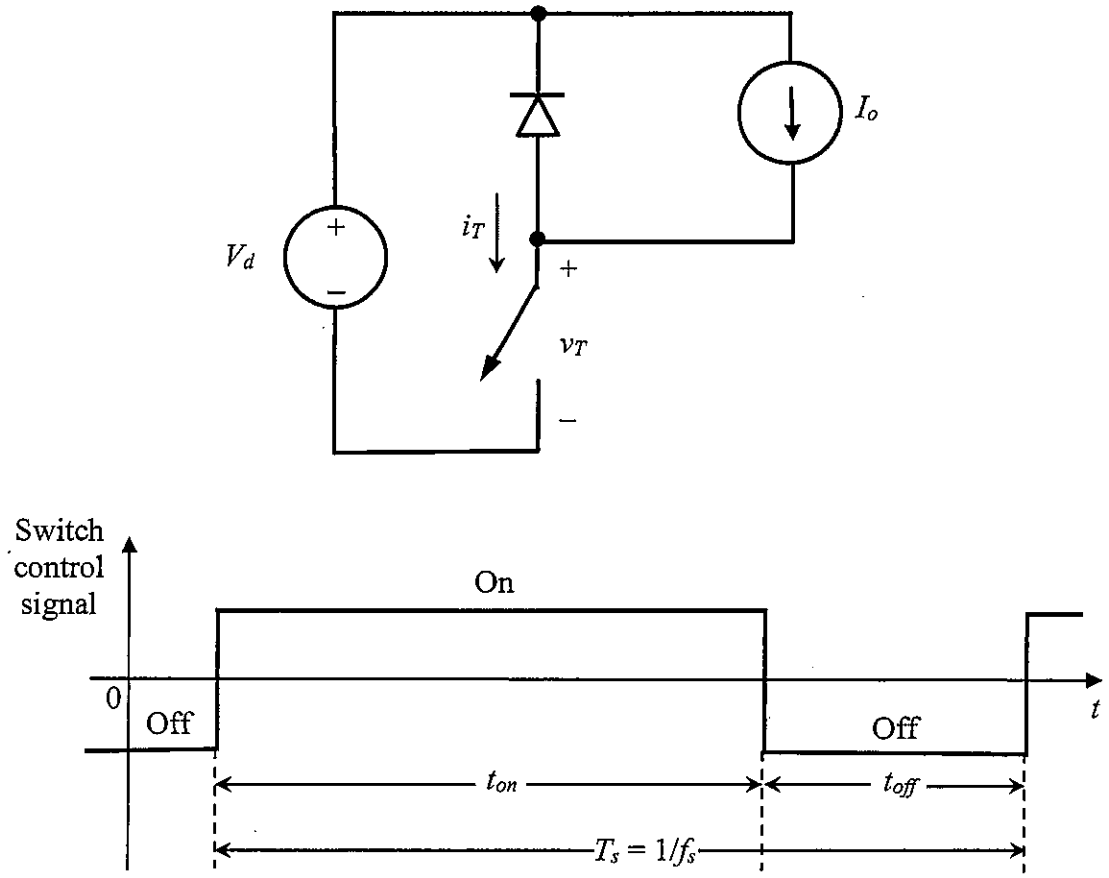

Figure Q1(a)

A controllable switch is connected in the simple circuit with switch control signal shown in Figure Q1(a).

(i) Based on the switch control signal, draw the switch waveforms for I_o, V_{on}, V_d and the instantaneous switch power loss. [4 marks]

Continue ...

Question 1

(b)(ii) The data sheets of a switching device specify the following switching times corresponding to the linearized characteristics shown in Figure Q1(a) for clamped-inductive switching:

t_{ri} = 100 ns, t_{fv} = 50 ns, t_{rv} = 100 ns, t_{fi} = 200 ns

Calculate the switching power loss of frequency 25 kHz and 100 kHz, assuming V_d = 300 V and I_o = 4 A in the circuit of Figure Q1(a). [8 marks]

(c) A power MOSFET is used as a switch to energize a resistive load at 100 kHz. The circuit and device parameters are given as below

Drain-source on state resistance, $R_{DS\text{-}on}$ = 0.03 Ω
On state current, $I_{D(on)}$ = 20 A
DC power supply, V_{DD} = 120 V
Turn on time, τ_{on} = 50 ns
Turn off time, τ_{off} = 200 ns

The MOSFET has negligible reverse leakage current. Determine

(i) the total power loss if the MOSFET has equal ON state and OFF state time. [4 marks]

(ii) the total power loss if the MOSFET switch at a duty cycle of 35%. [4 marks]

Continue ...

Question 2

(a) Given a diode with I_{peak} = 2.5 A has V_{th} = 1 V and R_{on} = 0.3 Ω in a rectifier circuit. Calculate for the power loss incurred in the diode. [6 marks]

(b) In a diode rectifier, the power flow can only be from the utility ac side to the dc side. The dc output voltage of a rectifier should be as ripple free as possible.

(i) Draw a block diagram of inexpensive rectifier with diode to convert the ac input to dc in an uncontrolled manner. [4 marks]

(ii) What is the normal practice to remove the ripple in a rectifier? [2 marks]

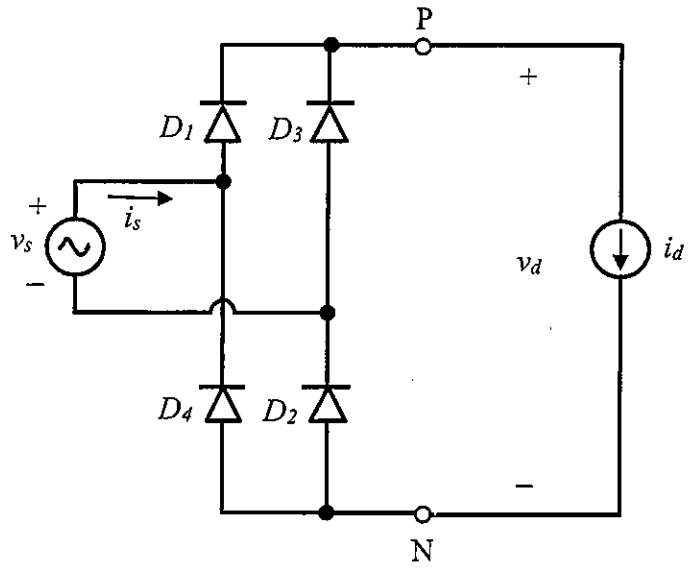

Figure Q2(a)

(c) In the single-phase diode rectifier circuit shown in Figure Q2(a) with zero L_s. and a constant dc current, I_d = 10 A, calculate the average power supplied to the load:

(i) If v_s is a sinusoidal voltage with V_s = 120 V at 60 Hz. [4 marks]

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Question 2

(c)(ii) If v_s has the pulse waveform shown in Figure Q2(b). [5 marks]

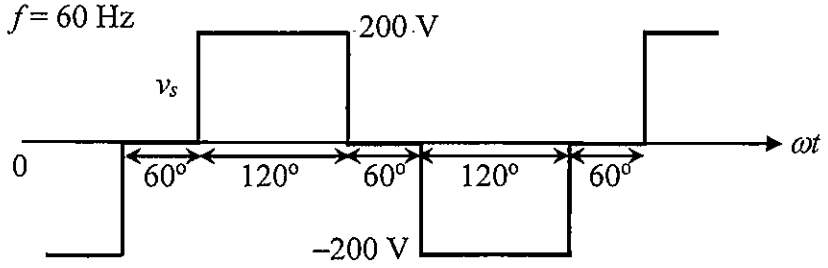

Figure Q2(b)

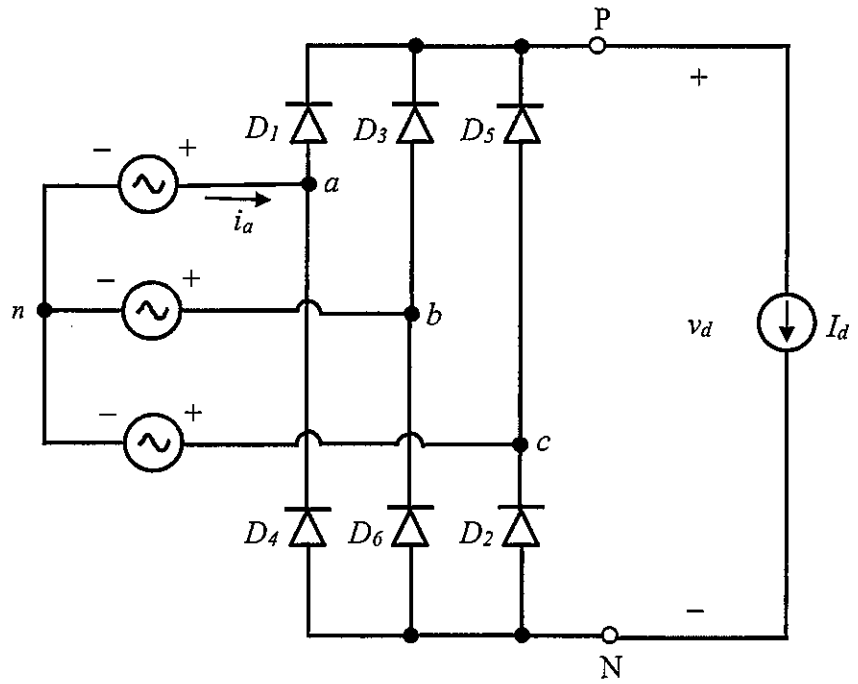

Figure Q2(c)

(d) In the simplified three-phase rectifier circuit of Figure Q2(c), obtain the average and the rms values of current through each diode as a ratio of the dc-side current I_d. [4 marks]

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Question 3

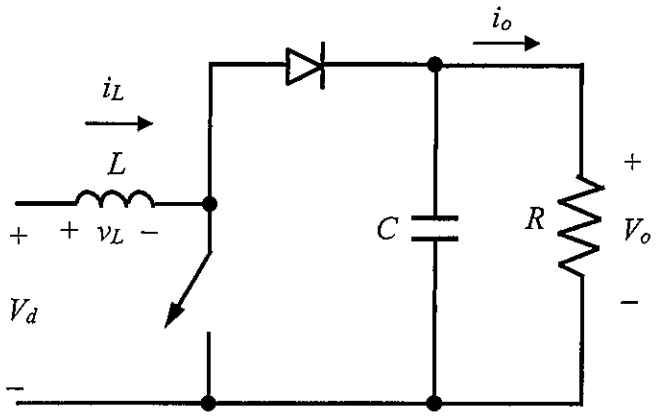

Figure Q3(a)

(a)(i) Give a main application of a step-up (boost) converter in Figure Q3(a). [2 marks]

(ii) Explain the switch on and switch off operation in this circuit. [3 marks]

(iii) Show the steady-state waveforms for this mode of conduction where the inductor current flows continuously [$i_L(t) > 0$]. [3 marks]

(iv) Draw the equivalent circuits during the switch on and switch off states. [4 marks]

(b) Consider all components to be ideal in a step-up converter. Let V_d be 8 - 16 V, V_o = 24 V (regulated), f_s = 20 kHz and C = 470 μF. Calculate L_{min} that will keep the converter operating in a continuous-conduction mode if $P_o \geq 5$ W. [7 marks]

(c) A buck-boost dc-dc converter has an input voltage of 12 V. The duty cycle of the switch is 0.4 and the switching frequency is 20 kHz. The value of filter inductance is 120 μH. Assuming the average load current is 1.5 A. Find

(i) Average output voltage. [2 marks]

(ii) Value of filter capacitance if the peak-to-peak output voltage ripple is 50 mV. [4 marks]

Continue ...

Question 4

(a)(i) Briefly explain the switch-mode inverter and its operation. [5 marks]

(ii) Give an example of its application. [2 marks]

(b) The voltage source inverters can be classified into (i) Pulse-width-modulated inverters and (ii) Square-wave inverters. Explain these two voltage source inverters. [2 + 2 marks]

(c) A single-phase full-bridge inverter is operated from a 48 V battery and is supplying power to a pure resistive load of 10 Ω. Find

(i) the fundamental output voltage. [2 marks]

(ii) output rms power and output fundamental power. [4 marks]

(d) A pulse width modulated (PWM) full-bridge inverter works from a 240 V dc input. The inverter frequency is 3 kHz. It is operating at a duty cycle of 70 %. Determine

(i) RMS value of the ac output voltage, [2 marks]

(ii) RMS value of the fundamental frequency component of the output ac voltage, $V_{1,rms} = 0.9V_s \sin\frac{D\pi}{2}$ [3 marks]

(iii) If the output voltage is to be reduced to 50% of the result in (i), what should be the new duty cycle? [3 marks]

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